ATTACHMENT E

2002 GEOTECHNICAL REPORT

Environmental
Geotechnical
Construction
Consulting • Engineering • Testing

May 14, 2002

Gould Evans Goodman Associates, LC
4041 Mill Street
Kansas City, Missouri 64111

Attn: Mr. Jim Schraeder

Re: Geotechnical Engineering Services Report
Whiteman Air Force Base
Family Housing Improvements
Knob Noster, Missouri
PSI File No. 338-25046

Dear Mr. Schraeder:

Professional Service Industries, Inc. is pleased to transmit our Geotechnical Engineering Services Report for the referenced project. This report includes the results of field and laboratory testing, and recommendations for foundation, as well as general site development.

We appreciate the opportunity to perform this Geotechnical Study and look forward to continued participation during the design and construction phases of this project. If you have any questions pertaining to this report, or if we may be of further service, please contact our office.

Respectfully submitted,

PROFESSIONAL SERVICE INDUSTRIES, INC.

David L. Richardson
Staff Engineer

STATE OF MISSOURI
KEVIN CLARK MILLER
NUMBER E-20701
REGISTERED PROFESSIONAL ENGINEER

5/14/02

Kevin C. Miller, P.E.
Chief Engineer
Missouri, E-20701
License Expires December 31, 2002

GEOTECHNICAL ENGINEERING SERVICES REPORT

WHITEMAN AIR FORCE BASE
FAMILY HOUSING IMPROVEMENTS
KNOB NOSTER, MISSOURI

PSI File No. 338-25046

PREPARED FOR

Mr. Jim Schraeder
Gould Evans Goodman Associates, LC
4041 Mill Street
Kansas City, Missouri 64111

Date: May 14, 2002

BY

PROFESSIONAL SERVICE INDUSTRIES, INC.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

An exploration and evaluation of the subsurface conditions has been completed for the proposed Family Housing Improvements at Whiteman Air Force Base in Knob Noster, Missouri. Test borings have been performed and selected soil samples tested in the laboratory. In general, beneath 2 to 4 inches of topsoil the subsurface materials consisted of fat clay underlain by weathered shale. Refusal materials were encountered in 5 of 10 borings at depths of 13.9 to 14.4 feet below the existing ground surface. Free groundwater was not measured in the borings at the completion of drilling.

The results of this exploration indicate that the subsurface conditions at the site are generally suitable for the use of conventional footing foundations for support of the proposed structural loads. The existing site soils are considered to be highly plastic and should be expected to exhibit characteristics of swell potential. It is our opinion that the on-site soils are not suitable for floor slab support. Recommendations for subgrade preparation are included in subsequent report sections. Details related to site development, foundation design, and construction considerations are included in subsequent sections of this report.

The owner/designer should not rely solely on this Executive Summary and must read and evaluate the entire contents of this report prior to utilizing our engineering recommendations in preparation of design/construction documents.

PROJECT INFORMATION

Project Authorization

Professional Service Industries, Inc. (PSI) has completed a geotechnical exploration for the proposed Family Housing Improvements at Whiteman Air Force Base in Knob Noster, Missouri. Our services were authorized by Mr. Gregory E. Nook, AIA of Gould Evans Goodman Associates, LC on February 11, 2002 by signing our proposal. This exploration was accomplished in general accordance with PSI Proposal No. 338-019 dated January 23, 2002.

Project Description

Project information was provided by Mr. Jim Schraeder of Gould Evans Goodman Associates, LC on January 22, 2002. PSI has also been furnished with a site plan. We understand the proposed construction will be as follows:

Building	• Eleven 2-Story Residences With Basements
	• Unknown Square Feet/Level
	• Column Loads Not Provided, Report Based on Not Exceeding 80 kips
	• Wall Loads Not Provided, Report Based on Not Exceeding 4 KLF
	• Grade Supported Floor Slab, Report Based on Not Exceeding 125 psf
Grading	• Unknown of Cut/Fill in and Adjacent to the Building Area
	• Unknown of Cut/Fill Across the Property

The geotechnical recommendations presented in this report are based on the available project information, building location, and the subsurface materials described in this report. If any of the noted information is incorrect, please inform PSI in writing so that we may amend the recommendations presented in this report if appropriate and if desired by the client. PSI will not be responsible for the implementation of its recommendations when it is not notified of changes in the project.

Purpose and Scope of Services

The purpose of this study was to explore the subsurface conditions at the site to provide recommendations for acceptable foundation systems for the proposed construction. Our scope of services included drilling 10 soil test borings at the site to depths of about 15 feet below the surface or refusal, whichever was shallower, select laboratory testing, and preparation of this geotechnical report. This report briefly outlines the testing procedures, presents available project information, describes the site and subsurface conditions, and presents recommendations regarding the following:

- - Grading procedures for site development.
- - Foundation types, depths, allowable bearing capacities, and an estimate of potential settlement.
- - Comments regarding factors that will impact construction and performance of the proposed construction.

The scope of services did not include an environmental assessment for determining the presence or absence of wetlands, or hazardous or toxic materials in the soil, bedrock, surface water, groundwater, or air on or below, or around this site. Any statements in this report or on the boring logs regarding odors, colors, and unusual or suspicious items or conditions are strictly for informational purposes.

SITE AND SUBSURFACE CONDITIONS

Site Location and Description

The site for the proposed Family Housing Improvements is located on Whiteman Airforce Base in Knob Noster, Missouri.

At the time of drilling, the ground surface cover consisted of grass, and surface drainage appeared to be good. A stream divided the site with Borings B-01, B-02, and B-10 on the east side of the stream and the remaining borings on the west side of the stream. The surface of the site was firm and the truck mounted drilling equipment did not experience difficulty in moving around the site, with the exception of crossing the stream to access the above-mentioned 3 borings.

Subsurface Conditions

The site subsurface conditions were explored with 10 soil test borings drilled within the proposed building areas. The boring locations and depths were selected by PSI after consulting with Gould Evans Goodman Associates, LC. The borings were located in the field by PSI personnel by measuring distances from known site landmarks shown on the site drawing. The borings were advanced utilizing 3¼-inch inside diameter hollow stem auger drilling methods and soil samples were routinely obtained during the drilling process. Drilling and sampling techniques were accomplished generally in accordance with ASTM procedures.

Selected soil samples were tested in the laboratory to determine material properties for our evaluation. Laboratory testing was accomplished generally in accordance with ASTM procedures.

The subsurface conditions identified by the 10 borings primarily included 2 strata. These materials are described in more detail in the following paragraphs.

The upper stratum of soils consisted of fat clay and extended from a depth of about 3 ½ to at least 15 feet below the existing ground surface. Please note that the fat clay soils extended to the terminal depths of borings B-05 and B-06. The results of the field and laboratory testing on this stratum indicate that the consistency of the fat clay is firm to stiff, with dry unit weights and moisture contents ranging from 91 pcf at 28 percent to 106 pcf at 24 percent. The soil is classified as CH according to the Unified Soil Classification System with a liquid limit ranging from 58 to 72 and a plasticity index ranging from 38 to 50. If this material is to be used for foundation support, its integrity should be verified by on-site testing and observations during construction.

Beneath the fat clay is a stratum of weathered shale that extended to the terminal depth of the borings at 15 feet below the existing ground surface, or to refusal. The results of the field and laboratory testing on this stratum indicate that the consistency of the weathered shale is hard, with dry unit weights and moisture contents ranging from 121 pcf at 12 percent to 123 pcf at 10 percent. The shale exhibited different amounts of weathering at the different boring locations.

Auger refusal materials were encountered at depths ranging from about 13.9 feet at Boring B-09 to 14.4 feet at Boring B-01. Refusal is a designation applied to material that cannot be penetrated by the power auger, and is normally indicative of a very hard or very dense material, such as boulders or lenses or the upper surface of bedrock. In addition to the refusal materials, weathered rock layers or pieces were encountered within the overburden soils at Borings B-06. Rock coring was beyond the scope of this exploration; therefore, the character and continuity of the refusal materials could not be determined.

The above subsurface description is of a generalized nature to highlight the major subsurface stratification features and material characteristics. The boring logs included in the

appendix should be reviewed for specific information at individual boring locations. These records include soil descriptions, stratifications, penetration resistances, locations of the samples, and laboratory test data. The stratifications shown on the boring logs represent the conditions only at the actual boring locations. Variations may occur and should be expected between boring locations. The stratifications represent the approximate boundary between subsurface materials and the actual transition may be gradual. Water level information obtained during drilling is also shown on these boring logs. The samples that were not altered by laboratory testing will be retained for 30 days from the date of this report and then will be discarded.

Groundwater Information

Free groundwater was not observed inside the boreholes upon completion of drilling, indicating that the continuous ground water level at the site at the time of the exploration was either below the terminated depths of the borings, or that the soils encountered were relatively impermeable. Although groundwater was not encountered at this time, it is possible for a groundwater table to be present within the depths explored during other times of the year depending upon climatic and rainfall conditions. Additionally, discontinuous zones of perched water may exist within the overburden materials and/or at the contact with bedrock.

EVALUATION AND RECOMMENDATIONS

Geotechnical Discussion

The following geotechnical related recommendations have been developed on the basis of the subsurface conditions encountered and our understanding of the proposed development. Should changes in the project criteria occur, a review must be made by PSI to determine if modifications to our recommendations will be required.

There are 2 primary concerns at this site, which will effect the performance and constructability of the residential structures. The following summarizes those concerns:

1. Fat clays were encountered which will impact the slab construction.
2. A surface drainage feature bisects the site on the western third of the property.

Fat Clay Considerations

Fat clays will be encountered at the proposed building site at depths that will likely impact the proposed construction. Fat clay soils have the potential for volume change with changes in the soil's moisture content. The volume change is normally evidenced by the heaving and cracking of concrete floor slabs. In severe cases, however, movement and distress to footings and foundation walls may occur. The geotechnical engineer should be provided with a set of final plans, when they are available, to assess the impact of the fat clay soils. PSI also recommends that the geotechnical engineer be contacted to inspect the subgrade soils in the portion of the building footprint where cuts are planned to determine the impact of the fat clay soils. Remedial measures, if recommended, would likely consist of overexcavating the fat clay materials to a depth of 2 feet beneath the proposed footing and floor slab subgrade elevation and replacement with compacted low plastic soils or granular fill materials. The remedial measures would likely be most economically performed at the initial stages of the general site grading. At that time, the unsuitable materials encountered could be removed from the proposed building area and could be placed as fill in selected areas of the site. Suitable fill materials could then be used as replacement fill in the overexcavated areas. Overexcavated footing excavations should extend at least 3 feet laterally in each direction to facilitate uniform compaction of the replacement fill materials. Lime-treatment or fly ash stabilization of the fat clay soils may be performed in lieu of the measures discussed above, for reducing the volume-change potential of the fat clay soils. Typically, between 5% to 15% lime or fly ash is added to the fat clay soil. The soil amendment should be thoroughly mixed by mechanical processes and placed to a depth of at least 2 feet below slabs and 3 feet below lightly loaded footings. The exact percentage of the amendment will vary with the soil parameters, material used, and means of placement. The remedial measures associated with the fat clay soils should be done at the direction of a representative of the geotechnical engineer.

Site Preparation

PSI recommends that topsoil, vegetation, roots, and soft soils in the construction areas be stripped from the site and either wasted or stockpiled for later use in landscaping. Topsoil in our borings ranged from 2 to 4 inches in thickness. It is typical for topsoil thickness to vary from these values. The depth of removal should be determined by a representative of the geotechnical engineer at the time of construction.

After stripping and excavating to the proposed subgrade level, as required, the building areas should be proof-rolled with a loaded tandem axle dump truck or similar rubber tired vehicle, typically with an axle load of 9 tons. Soils that are observed to rut or deflect excessively (typically greater than 1 inch) under the moving load should be undercut and replaced with properly compacted fill. The proof-rolling and undercutting activities should be witnessed by a

representative of the geotechnical engineer and should be performed during a period of dry weather. It is anticipated that soft soils will be encountered in the area of the drainage feature. Undercutting of the soft soils and replacement with structural fill will be necessary. A representative of the geotechnical engineer will need to observe the undercutting and determine at what depth competent material is reached. The subgrade soils should be scarified and compacted to at least 95 percent of the standard Proctor maximum dry density for a depth of at least 6 inches below the surface.

After subgrade preparation and observation have been completed, fill placement may begin. The first layer of fill material should be placed in a relatively uniform horizontal lift and be adequately keyed into the stripped and scarified subgrade soils. Fill materials should be free of organic or other deleterious materials, have a maximum particle size less than 3 inches, and have a liquid limit less than 45 and plasticity index less than 25. Most of the on-site soils are unsuitable for use as structural fill due to high plasticity. If a fine-grained silt or clay soil is used for fill, close moisture content control will be required to achieve the recommended degree of compaction. Structural fill should be compacted to at least 95 percent of standard Proctor maximum dry density.

Fine-grained silt or clay fill should be placed in maximum lifts of 8 inches of loose material and should be compacted within the range of –1 to +3 percentage points of the optimum moisture content value. Granular fill should be compacted within the range of –2 to +2 percentage points of the optimum moisture content value. If water must be added, it should be uniformly applied and thoroughly mixed into the soil by disking. Each lift of compacted engineered fill should be tested by a representative of the geotechnical engineer prior to placement of subsequent lifts.

Foundation Recommendations

The planned construction can be supported on conventional spread footing foundations bearing on the natural soils or properly compacted fill, as described in the "Site Preparation" section of this report. Spread footings for building columns and continuous footings for bearing walls can be designed for an allowable soil bearing pressure of 2500 psf, based on dead load plus design live load. Minimum dimensions of 24 inches for column footings and 18 inches for continuous footings should be used in foundation design to minimize the possibility of a local bearing capacity failure.

Exterior footings and footings in unheated areas should be located at a depth of at least 36 inches below the final exterior grade to provide adequate frost protection. If the building is to be constructed during the winter months or if footings will likely be subjected to freezing temperatures after foundation construction, then the footings should be adequately protected from freezing. Otherwise, interior footings can be located on the modified fat clay, weathered shale, or on compacted fill at nominal depths compatible with architectural and structural considerations.

Within individual spread footing locations where a combination of weathered bedrock and

soil are exposed at the design bearing elevations, remedial treatment will be necessary to provide a level, uniform bearing surface. PSI recommends that the soil portion be excavated to expose the weathered bedrock surface and the resulting excavation be backfilled to the proposed bearing level with lean concrete or dense graded crushed stone. In the event that only a small area of bedrock is exposed, the remedial treatment may consist of removing the bedrock to a depth of at least 2 feet below the footing contact level and then backfilling the resulting excavation with compacted structural fill.

Consolidation of the overburden resulting from the foundation loads will result in measurable increments of foundation settlements. Based on results of the field tests and the anticipated foundation loads, PSI estimates that the maximum foundation settlement will not exceed one inch. Differential settlement between two adjacent columns will probably approximate 75% of the total increment. Where adjacent foundations bear on dissimilar subgrades [i.e., one on soil, the other on bedrock], differential settlement will equal total settlement. While settlement of this magnitude is generally considered tolerable for structures of the type proposed, the design of masonry walls should include provisions for vertical control joints to minimize the affects of cosmetic "cracking".

The foundation excavations should be observed by a representative of PSI prior to steel or concrete placement to assess that the foundation materials are consistent with the materials discussed in this report. Soft or loose soil zones encountered at the bottom of the footing excavations should be removed to the level of weathered shale soils or adequately compacted fill as directed by the geotechnical engineer. Cavities formed as a result of excavation of soft or loose soil zones should be backfilled with lean concrete or dense graded compacted crushed stone.

After opening, footing excavations should be observed and concrete placed as quickly as possible to avoid exposure of the footing bottoms to wetting and drying. Surface run-off water should be drained away from the excavations and not be allowed to pond. The foundation concrete should be placed during the same day the excavation is made. If it is required that footing excavations be left open for more than one day, they should be protected to reduce evaporation or entry of moisture. This is extremely important to maintain the natural moisture content of the fat clays.

Floor Slab Recommendations

The floor slab can be grade supported on properly compacted structural fill. Proof-rolling, as discussed earlier in this report, should be accomplished to identify soft or unstable soils that should be removed from the floor slab area prior to fill placement and/or floor slab construction.

Moderate to high plastic (fat) clay soils, were encountered at depths that can impact the floor slab construction. Such soils have a potential for swelling with changes in the soil's moisture

content. This swelling can result in heaving and cracking of concrete floor slab. Please note that the weathered shale materials are also considered to be high plastic and have a potential for swelling. PSI recommends that on-grade floor slabs be supported on a minimum of 2 feet of low plasticity compacted fill, as described in the "Site Preparation" section of this report. This depth of fill may be achieved by elevating the site with fill and/or by undercutting natural soils in slab areas and replacing them with cohesive low plasticity compacted fill. The greater the thickness of low plasticity fill materials present beneath the slabs, the less probability of structural distress due to swelling of the plastic soils. It is important that the subgrade soils be maintained at or above standard Proctor optimum moisture content until concrete is placed. If the owner is willing to assume some additional risk of slab movement, the slab may be placed on the existing soils. It is important that the subgrade soils be maintained at or above standard Proctor optimum moisture content until concrete is placed.

In addition to the low plasticity fill indicated above, PSI recommends that a minimum 6-inch thick mat of well-graded crushed stone, with maximum particle size of ¾-inch and less than 5 percent passing the No. 4 sieve, be placed beneath the floor slab to enhance drainage. The quality of the granular material should be verified through laboratory testing prior to delivery and placement. Polyethylene sheeting may be placed within the granular mat to act as a vapor barrier if required by the design engineer. Prior to the placement of concrete, the granular material should be compacted with 4 passes of a vibratory plate compactor or large vibratory drum roller. The floor slab should have an adequate number of joints to reduce cracking resulting from differential movement and shrinkage. The floor slab should not be rigidly connected to columns, walls, or foundations unless it is designed as a structural slab.

Lateral Earth Pressure

Below-grade walls may be required to resist lateral earth pressures. These may include basement walls, loading dock walls and retaining or wing walls designed to accommodate surface grade changes around the building and parking areas or adjacent to truck ramps. The actual earth pressure on the walls will vary according to material types and backfill materials used and how the backfill is compacted. The equivalent fluid unit weights tabulated below provide recommended lateral earth pressures for design of these walls. This table assumes that positive foundation drainage is provided to prevent buildup of hydrostatic pressure.

Backfill Type	Fixed-Headed Walls (pcf)	Free-Headed Walls (pcf)
Cohesive Soil	70	55
Granular Material	60	45

The above values do not include the influence of foundation, slope, or surface load in or adjacent to the wall backfill. Fixed-Headed Walls are typically structurally restricted from moving laterally or rotating at the top of the wall. Free-Headed Walls, best illustrated by cantilever walls, both rotate and move laterally at the top of the wall in response to the soil load.

Backfill of foundation walls and retaining walls may consist of low plastic soils or granular material. The backfill materials should be placed in 8-inch thick loose layers and compacted to 95 percent of the standard Proctor maximum dry density according to ASTM D 698. PSI recommends that backfill directly behind the walls be compacted with light, hand-held compactors. Thinner lifts may be required for thorough compaction with hand held compactors. Heavy compactors and grading equipment should not be allowed to operate within 5 to 10 feet of the walls during backfilling to avoid developing excessive temporary or long-term lateral soil pressures. We recommend that a representative of the geotechnical engineer be present to monitor all foundation excavations and fill placement.

It is recommended that below-grade walls and retaining walls be provided with a positive foundation drainage system. A typical below-grade wall drain would consist of a minimum 4 inch flexible or rigid perforated drain pipe protected by a proper filter medium [clean, coarse granular fill] and a non-woven geotextile fabric. The non-woven filter fabric is intended to encircle or wrap the entire system. The foundation drain system should be tied to the storm drainage system, allowed to daylight downslope, or collected in a sump and pumped out. This system typically is installed directly on top of the footing with the free draining filter medium extending approximately 18 inches behind the wall and to within 2 feet of the final grade. This free draining material should be capped by 2 feet of relatively impervious soil and graded to provide drainage away from the wall to minimize the infiltration of surface water.

Earthquake and Seismic Design Considerations

A liquefaction analysis of the site was beyond the scope of this report. The 2000 International Building Code requires a site class for the calculation of earthquake design forces. This class is a function of soil type (i.e., depth of soil and strata types). Based on the depth to rock and the estimated shear strength of the soil at the boring locations, Site Class "D" is recommended. The USGS-NEHRP probabilistic ground motion values near latitude 38.7630° and longitude 93.5572°, which is approximately 5.5 kilometers from the registries nearest grid point, are as follows:

Period (seconds)	2% Probability of Event in 50 years* (%g)
PGA	5.419490
0.2	12.692440
0.3	12.157580

1.0	17.000

* At the nearest grid point (lat: 38.8, long: -93.6)

CONSTRUCTION CONSIDERATIONS

PSI should be retained to provide observation and testing of construction activities involved in the foundation, earthwork, and related activities of this project. PSI cannot accept any responsibility for any conditions that deviated from those described in this report, nor for the performance of the foundation if not engaged to also provide construction observation and testing for this project.

Moisture Sensitive Soils/Weather Related Concerns

The upper fine-grained soils encountered at this site are expected to be sensitive to disturbances caused by construction traffic and changes in moisture content. During wet weather periods, increases in the moisture content of the soil can cause significant reduction in the soil strength and support capabilities. In addition, soils that become wet may be slow to dry and thus significantly retard the progress of grading and compaction activities. It will, therefore, be advantageous to perform earthwork and foundation construction activities during dry weather.

Plastic Soil Considerations

Due to the highly plastic nature of on-site soils, some of which may be left in place, consideration should be given to these soils to reduce their shrink/swell potential. Simply stated, clays expand or shrink by absorbing or losing moisture. Controlling the moisture content variation of a soil will therefore reduce its variation in volume. A number of measures may be used to attain a reduction in subsoil moisture content variations, thus reducing the shrink/swell potential. Some of these measures are outlined below.

1 - During construction, a positive surface drainage scheme should be implemented to prevent ponding of water on the subgrade.

2 - The building and pavement subgrades should not be allowed to dry out; foundation backfill should proceed as soon as possible after construction to minimize changes in the soils natural moisture.

3 - Positive surface drainage should be maintained around buildings through a roof/gutter

system connected to piping or paved surfaces, transmitting water away from the foundation perimeter, in addition to positive grades sloping away from the foundations.

4 - Utility trenches should be backfilled with low plastic clays to reduce the potential of the trenches acting as aqueducts and transmitting water beneath the structure or pavement due to excessive surface water infiltration.

5 - Shrubbery or flowerbeds surrounding the buildings should be planned to insure that bedding soils drain away from the building. Planters should have impermeable bases with weep holes directed onto the pavement surface.

All project features beyond the scope of those discussed above should be planned and designed similarly to attain a region of relatively constant moisture content in the foundation and floor slab areas.

Drainage and Groundwater Concerns

Water should not be allowed to collect in the foundation excavation, on floor slab areas, or on prepared subgrades of the construction area either during or after construction. Undercut or excavated areas should be sloped toward one corner to facilitate removal of any collected rainwater, groundwater, or surface runoff. Positive site drainage should be provided to reduce infiltration of surface water around the perimeter of the building and beneath the floor slabs. The grades should be sloped away from the building and surface drainage should be collected and discharged such that water is not permitted to infiltrate the backfill and floor slab areas of the building.

While groundwater was not encountered at the time the field exploration was conducted, at depths that would effect shallow foundation construction, it is possible that seasonal variations will cause fluctuations or a water table to be present in the upper soils. Additionally, perched water may be encountered in discontinuous zones within the overburden and/or near the contact with bedrock. Any water accumulation should be removed from excavations by pumping. Should excessive and uncontrolled amounts of seepage occur, the Geotechnical Engineer should be consulted.

Due to the potential for a significant amount of below grade construction, groundwater considerations should be included in the design of this structure. These include, but are not limited to, drainage for below grade walls and floor slabs, removal of water during construction, and the construction of subsurface drains to continually remove groundwater from the building areas.

Free groundwater was not observed to have collected in any of the test holes at the time of drilling. We anticipate, however, that isolated areas of perched groundwater may be encountered overlying the bedrock or the plastic clay soils. We recommend that the Contractor determine the

actual groundwater level at the site at the time of the construction activities.

Excavations

Auger refusal materials were encountered at depths of 13.9 to 14.4 feet below the existing grade in 5 of the borings. Auger refusal conditions generally correspond to materials that require blasting for removal. Typically, soils penetrated by augers can be removed with conventional earthmoving equipment. However, excavation equipment varies, and field refusal conditions may vary. In addition, weathered shale was encountered at elevations above the assumed basement elevation. Generally, the weathering process is erratic and variations in the partially weathered rock or rock profile can occur in small lateral distances. Therefore, it is possible that some partially weathered rock and/or rock pinnacles or ledges requiring difficult excavation techniques may be encountered in site areas between our boring locations.

Materials removed from the excavation should not be stockpiled immediately adjacent to the excavation, inasmuch as this load may cause a sudden collapse of the embankment. A slope stability analysis should be performed to determine the factor of safety for cut or fill slopes.

In Federal Register, Volume 54, No. 209 (October 1989), the United States Department of Labor, Occupational Safety and Health Administration (OSHA) amended its "Construction Standards for Excavations, 29 CFR, part 1926, Subpart P". This document was issued to better insure the safety of workmen entering trenches or excavations. It is mandated by this federal regulation that excavations, whether they be utility trenches, basement excavation or footing excavations, be constructed in accordance with the new OSHA guidelines. It is our understanding that these regulations are being strictly enforced and if they are not closely followed the owner and the contractor could be liable for substantial penalties.

The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. The contractor's "responsible person", as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations.

PSI is providing this information solely as a service to our client. We do not assume responsibility for construction site safety or the contractor's or other parties' compliance with local, state, and federal safety or other regulations.

REPORT LIMITATIONS

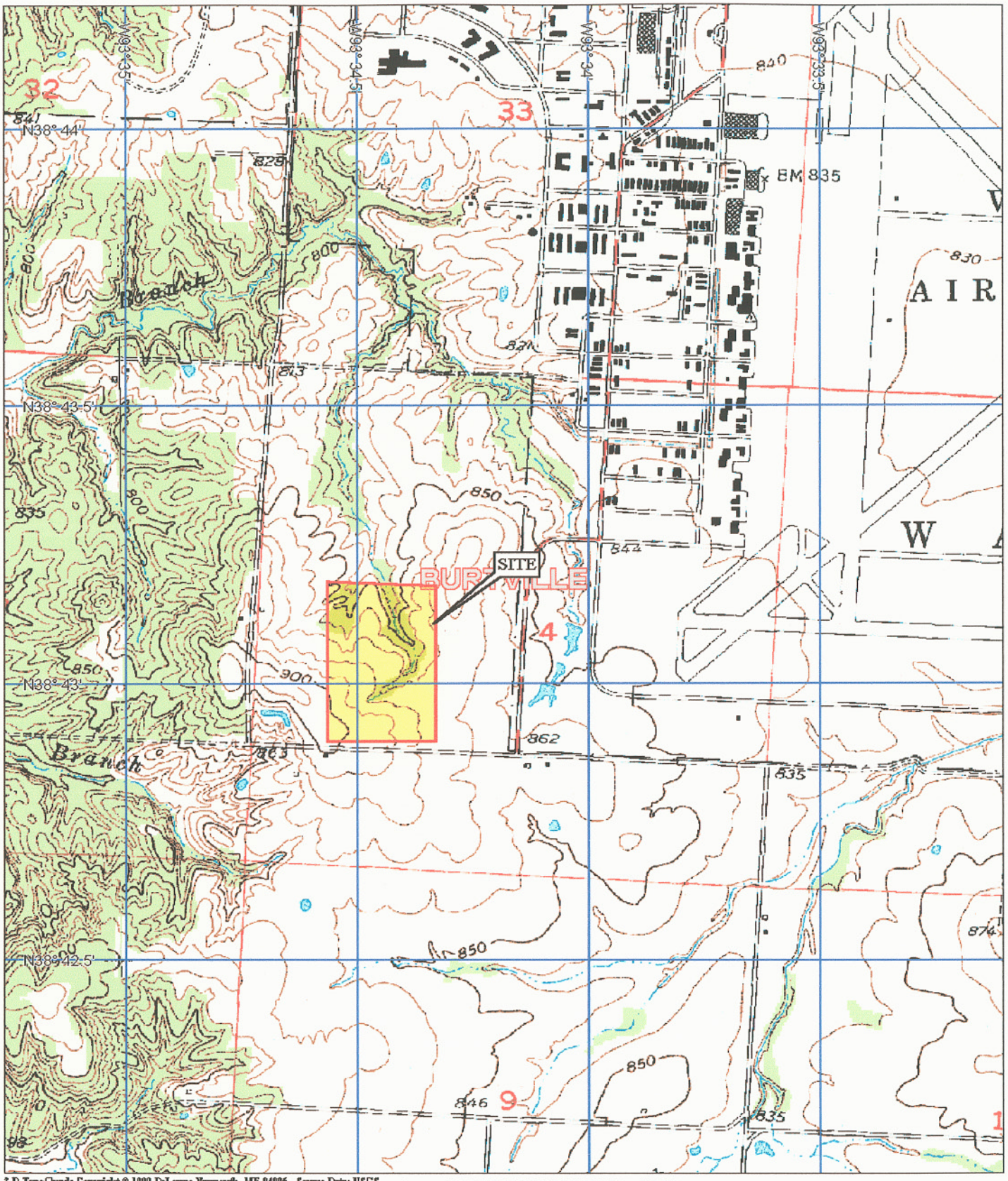
The recommendations submitted are based on the available subsurface information obtained by PSI and design details furnished by Gould Evans Goodman Associates, LC for the proposed project. If there are any revisions to the plans for this project or if deviations from the subsurface conditions noted in this report are encountered during construction, PSI should be notified immediately to determine if changes in the foundation recommendations are required. If PSI is not retained to perform these functions, PSI will not be responsible for the impact of those conditions on the project.

The geotechnical engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted professional geotechnical engineering practices in the local area. No other warranties are implied or expressed.

After the plans and specifications are more complete, the geotechnical engineer should be retained and provided the opportunity to review the final design plans and specifications to check that our engineering recommendations have been properly incorporated into the design documents. At this time, it may be necessary to submit supplementary recommendations. This report has been prepared for the exclusive use of Gould Evans Goodman Associates, LC for the specific application to the proposed Family Housing Improvements.

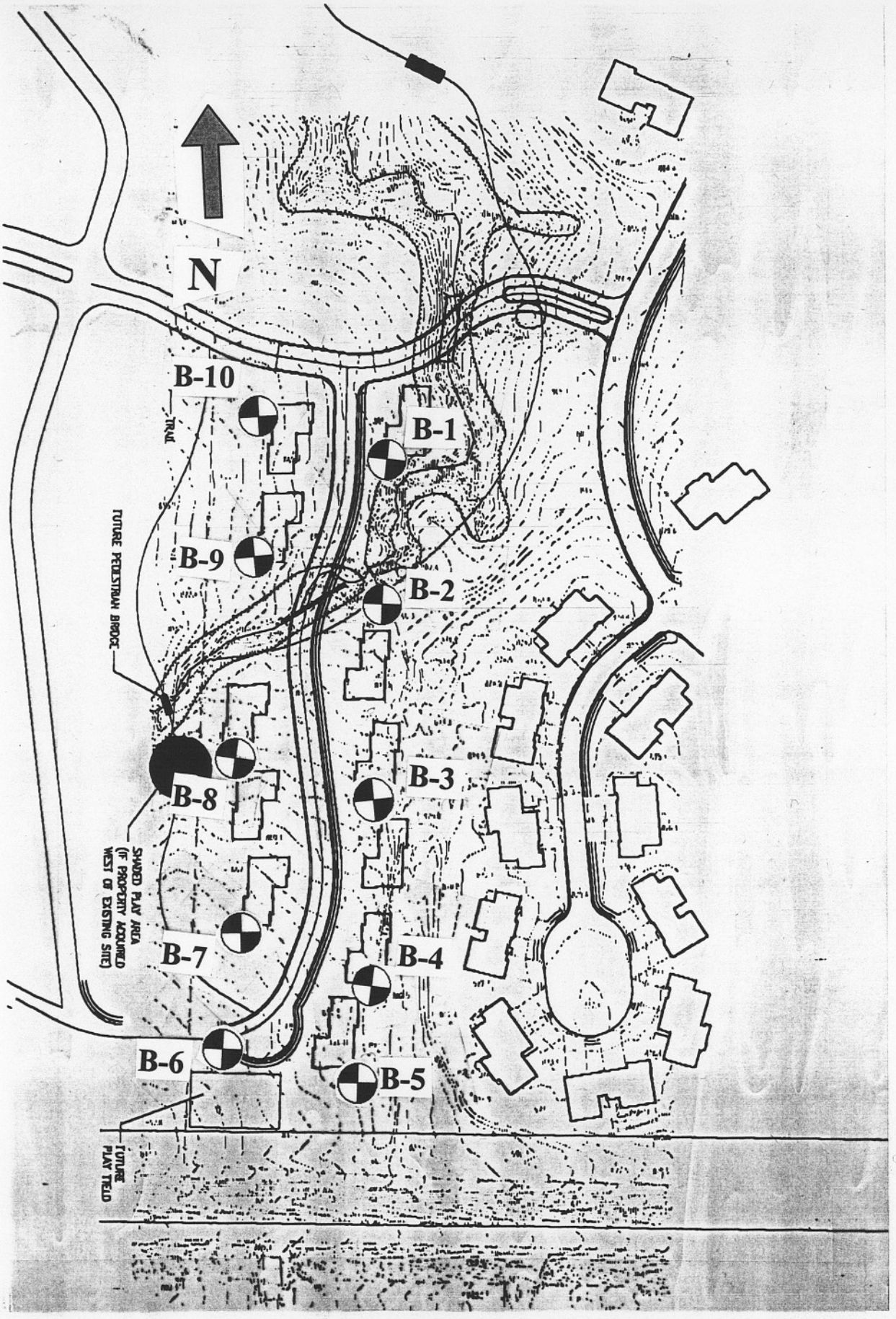
APPENDIX I

Professional Service Industries, Inc.



USGS Topographic Map Date: 1999 Revised:	Figure 1: Site Vicinity Map Whiteman Air Force Base Family Housing Improvements Knob Noster, Missouri	PSI Project No.:	338-25046
		Date: 5/14/02	Drawn By: DLR

Professional Service Industries, Inc.



Boring Location Diagram **(not to scale)**	**Figure 2** **Whiteman Air Force Base** **Family Housing Improvements** **Knob Noster, Missouri**	**PSI Project No.:**	**338-25046**
		Date: **5/14/02**	**Drawn By:** **DLR**

APPENDIX II

PSI
4106 NW Riverside Drive
Riverside, Missouri 64150
Telephone: 816-741-9466
Fax: 816-741-0613

LOG OF BORING B-01

Figure No. 3

PSI Job No.: 338-25046
Project: Proposed Improved Family Housing
Location: Whiteman Air Force Base
Knob Noster, Missouri

Drilling Method: Hollow-Stem Auger
Hammer Type: Automatic
Latitude:
Longitude:

WATER LEVELS

Elevation, (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	USCS Classification	MATERIAL DESCRIPTION	SPT Blows/N-Value	Dry Density (pcf)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (1–25–50) STRENGTH, tsf ▲ Qu ✳ Qp (0–2.0–4.0)	Additional Remarks
						Surface Elev.:					
	0					TOPSOIL - 3 inches.					
				1	CH	FAT CLAY - Firm, moist, brown.		102	22	▲ × ✳	Qu = 1.2 tsf Qp = 3.75 tsf
	5			2		WEATHERED SHALE - Hard, moist, light brown.	24-37-48 N=85		8	× >>◎	
	10			3			10-50/5.5"		11	×	
				4		SANDSTONE.	12-50/4"		10	×	

Completion Depth: 14.4 ft
Date Boring Started: 4/29/02
Date Boring Completed: 4/29/02
Logged By: R. Sturtridge
Drilling Contractor: PSI

Sample Types:
Auger Cutting
Split-Spoon
Rock Core
Shelby Tube
Hand Auger

Remarks:

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING B-02

Figure No. 4

PSI Job No.:	338-25046	Drilling Method:	Hollow-Stem Auger	WATER LEVELS
Project:	Proposed Improved Family Housing	Hammer Type:	Automatic	
Location:	Whiteman Air Force Base Knob Noster, Missouri	Latitude: Longitude:		

Elevation, (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	USCS Classification	MATERIAL DESCRIPTION	SPT Blows/N-Value	Dry Density (pcf)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (1–25–50) STRENGTH, tsf ▲ Qu ✳ Qp (0–2.0–4.0)	Additional Remarks
						Surface Elev.:					
	0				CH	TOPSOIL - 2 inches. FAT CLAY - Stiff, moist, brown.					
				1				102	23	× >>✳	Qu = 6.8 tsf Qp = 4.50 tsf
	5			2				113	20	× >>✳	Qu = 7.6 tsf Qp = 4.50 tsf
						WEATHERED SHALE - Hard, moist, light brown.					
	10			3			20-50/3"		10	×	
						WEATHERED SHALE - With weathered sandstone.					
				4		SANDSTONE.	50/5"		15	×	

Completion Depth:	14.0 ft
Date Boring Started:	4/29/02
Date Boring Completed:	4/29/02
Logged By:	R. Sturtridge
Drilling Contractor:	PSI

Sample Types:
Auger Cutting
Split-Spoon
Rock Core
Shelby Tube
Hand Auger

Remarks:

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING B-03

Figure No. 5

PSI Job No.:	338-25046	Drilling Method:	Hollow-Stem Auger	WATER LEVELS
Project:	Proposed Improved Family Housing	Hammer Type:	Automatic	
Location:	Whiteman Air Force Base Knob Noster, Missouri	Latitude: Longitude:		

Elevation, (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	USCS Classification	MATERIAL DESCRIPTION	SPT Blows/N-Value	Dry Density (pcf)	Moisture, %	STANDARD PENETRATION TEST DATA (N in blows/ft ◎; × Moisture; ◪ PL; ✚ LL; 1–25–50) / STRENGTH, tsf (▲ Qu; ✳ Qp; 0–2.0–4.0)	Additional Remarks
						Surface Elev.:					
	0					TOPSOIL - 3 1/2 inches.					
					CH	FAT CLAY - Stiff, moist, light brown.					
				1				104	21	◪× → ◎	LL = 58% PL = 19% Qu = 11.1 tsf Qp = 4.50 tsf
	5			2				105	20	× ▲ ✳	Qu = 2.8 tsf Qp = 3.75 tsf
						WEATHERED SHALE - Hard, moist, light brown.					
	10			3			5-21-31 N=52		15	× → ◎	
				4			34-50/3"		17	×	
						SHALE - Hard, moist, light brown.					

Completion Depth:	14.3 ft
Date Boring Started:	4/29/02
Date Boring Completed:	4/29/02
Logged By:	R. Sturtridge
Drilling Contractor:	PSI

Sample Types:
Auger Cutting; Split-Spoon; Rock Core; Shelby Tube; Hand Auger

Remarks:

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING B-04

Figure No. 6

PSI Job No.:	338-25046	Drilling Method:	Hollow-Stem Auger	WATER LEVELS
Project:	Proposed Improved Family Housing	Hammer Type:	Automatic	
Location:	Whiteman Air Force Base Knob Noster, Missouri	Latitude: Longitude:		

Elevation, (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	USCS Classification	MATERIAL DESCRIPTION	SPT Blows/N-Value	Dry Density (pcf)	Moisture, %	STANDARD PENETRATION TEST DATA (N in blows/ft ◎; × Moisture; ◪ PL; ✚ LL; 1–25–50) / STRENGTH, tsf (▲ Qu; ✳ Qp; 0–2.0–4.0)	Additional Remarks
	0					Surface Elev.:					
					CH	TOPSOIL - 3 inches. FAT CLAY - Firm to stiff, moist, brown.					
				1				106	22	× ; >▲	Qu = 3.8 tsf Qp = 4.50 tsf
	5			2				96	28	▲ ×	Qu = 1.9 tsf Qp = 2.00 tsf
	10			3			3-8-14 N=22		15	× ◎	
						WEATHERED SHALE - Hard, moist, light brown.					
				4			11-24-40 N=64		15	× ; >>◎	
	15										

Completion Depth:	15.0 ft	Sample Types:	Remarks:
Date Boring Started:	4/29/02	Auger Cutting; Split-Spoon; Rock Core; Shelby Tube; Hand Auger	
Date Boring Completed:	4/29/02		
Logged By:	R. Sturtridge		
Drilling Contractor:	PSI		

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING B-05

Figure No. 7

PSI Job No.:	338-25046	Drilling Method:	Hollow-Stem Auger	WATER LEVELS
Project:	Proposed Improved Family Housing	Hammer Type:	Automatic	
Location:	Whiteman Air Force Base Knob Noster, Missouri	Latitude: Longitude:		

Elevation, (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	USCS Classification	MATERIAL DESCRIPTION	SPT Blows/N-Value	Dry Density (pcf)	Moisture, %	STANDARD PENETRATION TEST DATA (N in blows/ft ◎; × Moisture; ◪ PL; ✚ LL; 1–25–50) / STRENGTH, tsf (▲ Qu; ✳ Qp; 0–2.0–4.0)	Additional Remarks
	0					Surface Elev.:					
					CH	TOPSOIL - 3 inches. FAT CLAY - Soft to stiff, moist, light brown.					
				1				100	24		Qp = 1.75 tsf
	5			2				94	25		Qu = 2.2 tsf Qp = 2.25 tsf
	10			3				100	29		Qu = 0.7 tsf Qp = 4.50 tsf
				4			10-23-47 N=70	114	15		Qu = 3.0 tsf
	15										

Completion Depth:	15.0 ft
Date Boring Started:	4/29/02
Date Boring Completed:	4/29/02
Logged By:	R. Sturtridge
Drilling Contractor:	PSI

Sample Types:
Auger Cutting; Split-Spoon; Rock Core; Shelby Tube; Hand Auger

Remarks:

The stratification lines represent approximate boundaries. The transition may be gradual.

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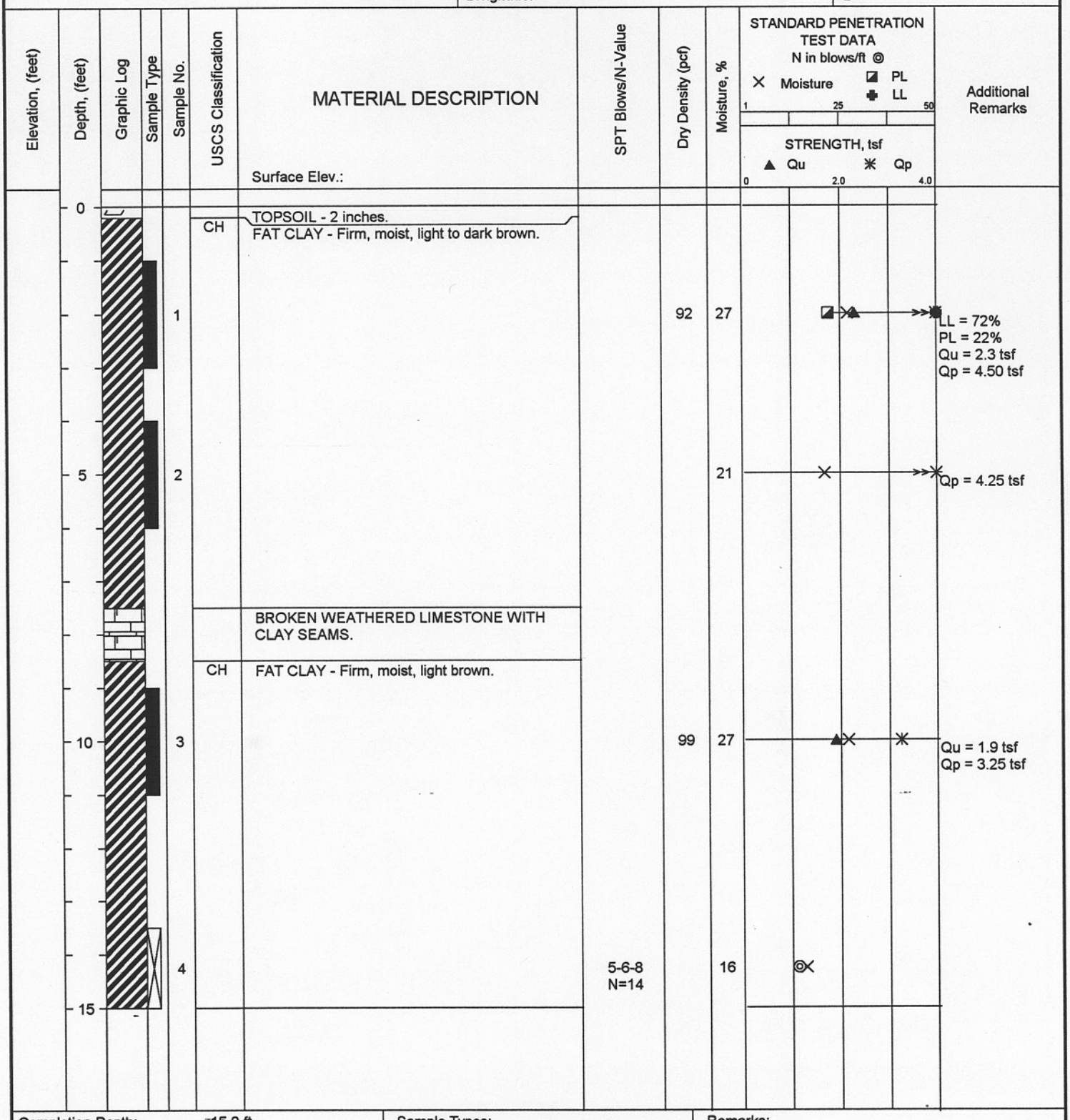
LOG OF BORING B-06

Figure No. 8

PSI Job No.: 338-25046
Project: Proposed Improved Family Housing
Location: Whiteman Air Force Base
Knob Noster, Missouri

Drilling Method: Hollow-Stem Auger
Hammer Type: Automatic
Latitude:
Longitude:

WATER LEVELS



Completion Depth: 15.0 ft
Date Boring Started: 4/29/02
Date Boring Completed: 4/29/02
Logged By: R. Sturtridge
Drilling Contractor: PSI

Sample Types:
Auger Cutting
Split-Spoon
Rock Core
Shelby Tube
Hand Auger

Remarks:

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING B-07

Figure No. 9

PSI Job No.:	338-25046	Drilling Method:	Hollow-Stem Auger	WATER LEVELS
Project:	Proposed Improved Family Housing	Hammer Type:	Automatic	
Location:	Whiteman Air Force Base Knob Noster, Missouri	Latitude: Longitude:		

Elevation, (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	USCS Classification	MATERIAL DESCRIPTION	SPT Blows/N-Value	Dry Density (pcf)	Moisture, %	STANDARD PENETRATION TEST DATA (N in blows/ft ◎; × Moisture; ◪ PL; ✚ LL; 1–25–50) / STRENGTH, tsf (▲ Qu; ✳ Qp; 0–2.0–4.0)	Additional Remarks
						Surface Elev.:					
	0					TOPSOIL - 4 inches.					
					CH	FAT CLAY - Stiff, moist, light brown.					
				1				100	21	× ; >> ✳	Qu = 5.3 tsf Qp = 4.25 tsf
	5			2						>> ✳	Qp = 4.50 tsf
	10			3		SHALE - Hard, moist, light brown.	4-19-22 N=41	121	12	× ; ◎	
				4			6-16-36 N=52		16	× ; >> ◎	
	15										

Completion Depth:	15.0 ft	Sample Types:		Remarks:
Date Boring Started:	4/29/02	Auger Cutting	Shelby Tube	
Date Boring Completed:	4/29/02	Split-Spoon	Hand Auger	
Logged By:	R. Sturtridge	Rock Core		
Drilling Contractor:	PSI			

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING B-08

Figure No. 10

PSI Job No.:	338-25046	Drilling Method:	Hollow-Stem Auger
Project:	Proposed Improved Family Housing	Hammer Type:	Automatic
Location:	Whiteman Air Force Base Knob Noster, Missouri	Latitude: Longitude:	

WATER LEVELS

Elevation, (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	USCS Classification	MATERIAL DESCRIPTION	SPT Blows/N-Value	Dry Density (pcf)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture ◪ PL ✚ LL (1–25–50) STRENGTH, tsf ▲ Qu ✳ Qp (0–2.0–4.0)	Additional Remarks
	0					Surface Elev.:					
					CH	TOPSOIL - 3 inches. FAT CLAY - Firm, moist, brown.					
				1				94	27	▲ ✳	Qu = 1.1 tsf Qp = 2.50 tsf
	5			2				102	21	✳ →	Qu = 1.7 tsf Qp = 4.50 tsf
						WEATHERED SHALE - Hard, moist, light brown to gray.					
	10			3			8-20-38 N=58		15	× >>◎	
	15			15			16-44-48 N=92		13	× >>◎	

Completion Depth:	15.0 ft
Date Boring Started:	4/29/02
Date Boring Completed:	4/29/02
Logged By:	R. Sturtridge
Drilling Contractor:	PSI

Sample Types:
Auger Cutting
Split-Spoon
Rock Core
Shelby Tube
Hand Auger

Remarks:

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING B-09

Figure No. 11

PSI Job No.:	338-25046	Drilling Method:	Hollow-Stem Auger	WATER LEVELS
Project:	Proposed Improved Family Housing	Hammer Type:	Automatic	
Location:	Whiteman Air Force Base Knob Noster, Missouri	Latitude: Longitude:		

Elevation, (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	USCS Classification	MATERIAL DESCRIPTION	SPT Blows/N-Value	Dry Density (pcf)	Moisture, %	STANDARD PENETRATION TEST DATA (N in blows/ft ◎; × Moisture; ◪ PL; ✚ LL; 1–25–50) / STRENGTH, tsf (▲ Qu; ✳ Qp; 0–2.0–4.0)	Additional Remarks
	0					Surface Elev.:					
						TOPSOIL - 4 inches.					
					CH	FAT CLAY - Firm to stiff, moist, brown.					
				1				91	28	✳ × Qp	Qp = 1.50 tsf
	5			2				106	24	✳ × ▲ Qu	Qu = 2.8 tsf Qp = 1.75 tsf
						SHALE - Hard, moist, light brown.					
	10			3			8-14-28 N=42		14	× ◎	
				4			50/4"	123	10	×	

Completion Depth:	13.9 ft	Sample Types:		Remarks:
Date Boring Started:	4/29/02	Auger Cutting	Shelby Tube	
Date Boring Completed:	4/29/02	Split-Spoon	Hand Auger	
Logged By:	R. Sturtridge	Rock Core		
Drilling Contractor:	PSI			

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING B-10

Figure No. 12

PSI Job No.:	338-25046	Drilling Method:	Hollow-Stem Auger	WATER LEVELS
Project:	Proposed Improved Family Housing	Hammer Type:	Automatic	
Location:	Whiteman Air Force Base Knob Noster, Missouri	Latitude: Longitude:		

Elevation, (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	USCS Classification	MATERIAL DESCRIPTION	SPT Blows/N-Value	Dry Density (pcf)	Moisture, %	STANDARD PENETRATION TEST DATA (N in blows/ft ◎; × Moisture; ◪ PL; ✚ LL; 1–25–50) / STRENGTH, tsf (▲ Qu; ✳ Qp; 0–2.0–4.0)	Additional Remarks
	0					Surface Elev.:					
					CH	TOPSOIL - 4 inches. FAT CLAY - Firm, moist, brown.					
				1				91	27		LL = 59% PL = 21% Qu = 1.3 tsf Qp = 1.25 tsf
	5			2				96	27		Qu = 1.0 tsf Qp = 2.25 tsf
						SANDSTONE - some shale, hard, moist, light brown.					
	10			3			50/5"		12		
				4			35-50/2"		10		

Completion Depth:	14.3 ft
Date Boring Started:	4/29/02
Date Boring Completed:	4/29/02
Logged By:	R. Sturtridge
Drilling Contractor:	PSI

Sample Types:
Auger Cutting; Split-Spoon; Rock Core; Shelby Tube; Hand Auger

Remarks:

The stratification lines represent approximate boundaries. The transition may be gradual.

APPENDIX III

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Qu (tsf)	%<#4 Sieve	%<#200 Sieve	Water Content (%)	Dry Density (pcf)	Remarks
B-01	1.0				1.2			22	102	
B-01	4.5							8		
B-01	9.5							11		
B-01	13.5							10		
B-02	1.0				6.8			23	102	
B-02	4.0				7.6			20	113	
B-02	9.5							10		
B-02	13.5							15		
B-03	1.0	58	19	38	11.1			21	104	
B-03	4.0				2.8			20	105	
B-03	9.5							15		
B-03	13.5							17		
B-04	1.0				3.8			22	106	
B-04	4.0				1.9			28	96	
B-04	9.5							15		
B-04	13.5							15		
B-05	1.0							24	100	
B-05	4.0				2.2			25	94	
B-05	9.0				0.7			29	100	
B-05	13.5				3.0			15	114	
B-06	1.0	72	22	50	2.3			27	92	
B-06	4.0							21		
B-06	9.0				1.9			27	99	
B-06	13.5							16		
B-07	1.0				5.3			21	100	
B-07	9.5							12	121	
B-07	13.5							16		
B-08	1.0				1.1			27	94	
B-08	4.0				1.7			21	102	
B-08	9.5							15		
B-08	13.5							13		
B-09	1.0							28	91	
B-09	4.0				2.8			24	106	
B-09	9.5							14		
B-09	13.5							10	123	
B-10	1.0	59	21	39	1.3			27	91	
B-10	4.0				1.0			27	96	
B-10	9.5							12		
B-10	13.5							10		

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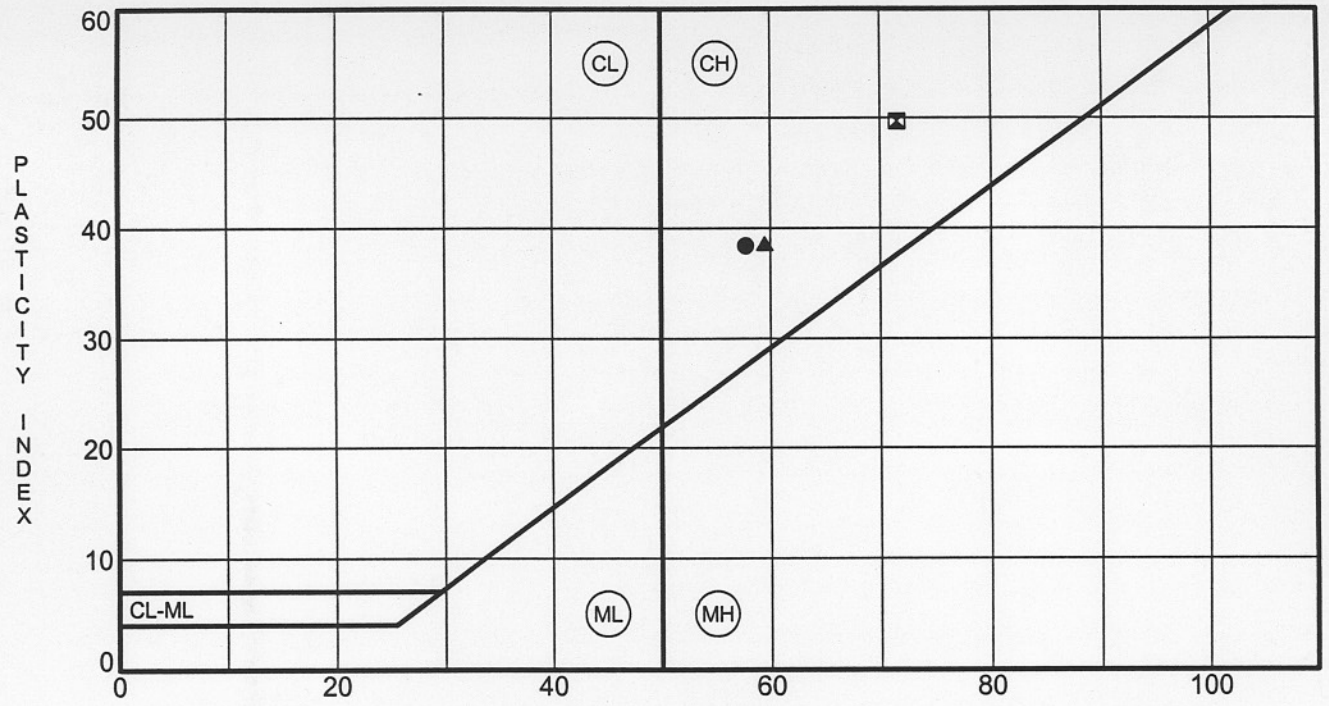
Summary of Laboratory Results

PSI Job No.: 338-25046
Project: Proposed Improved Family Housing
Location: Whiteman Air Force Base
Knob Noster, Missouri



	Boring	Depth (ft)	LL	PL	PI	Fines	Classification
●	B-03	1.0	58	19	39		
⊠	B-06	1.0	72	22	50		
▲	B-10	1.0	59	21	38		

ATTERBERG LIMITS' RESULTS

PSI Job No.: 338-25046
Project: Proposed Improved Family Housing
Location: Whiteman Air Force Base
Knob Noster, Missouri